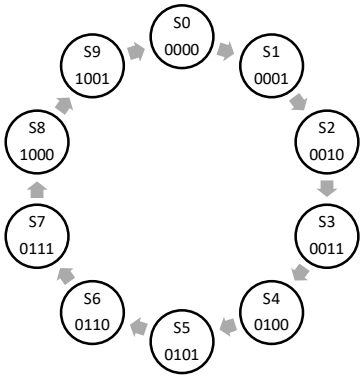
ASSIGNMENT – 6

Design BCD counter, counting from zero to 9. Demonstrate with hard ware using Flip Flops. You can generate the low frequency using Arduino.

A BCD counter (counting from 0 to 9) is a Modulo 10 counter and we require at least 4 F/F to implement it. As the counter is synchronous, all the 4 FF are clocked by the same clock with is a square wave provided using Arduino.

Here we use JK Flip Flop as the implementation is easier than using a D Flip Flop.

STATE DIAGRAM



STATE TABLE

PRESENT STATE												NEXT STATE			
Q3	Q2	Q1	Q0	J3	K3	J2	K2	J1	K1	J0	K0	Q3	Q2	Q1	Q0
0	0	0	0	0	X	0	X	0	X	1	X	0	0	0	1
0	0	0	1	0	X	0	X	1	X	X	1	0	0	1	0
0	0	1	0	0	X	0	X	X	0	1	X	0	0	1	1
0	0	1	1	0	X	1	X	X	1	X	1	0	1	0	0
0	1	0	0	0	X	X	0	0	X	1	X	0	1	0	1
0	1	0	1	0	X	X	0	1	X	X	1	0	1	1	0
0	1	1	0	0	X	X	0	X	0	1	X	0	1	1	1
0	1	1	1	1	X	X	1	X	1	X	1	1	0	0	0
1	0	0	0	X	0	0	X	0	X	1	X	1	0	0	1
1	0	0	1	X	1	0	X	0	X	X	1	0	0	0	0
1	0	1	0	X	X	X	X	X	X	X	X	X	X	X	X
1	0	1	1	X	X	X	X	X	X	X	X	X	X	X	X
1	1	0	0	X	X	X	X	X	X	X	X	X	X	X	X
1	1	0	1	X	X	X	X	X	X	X	X	X	X	X	X
1	1	1	0	X	X	X	X	X	X	X	X	X	X	X	X
1	1	1	1	X	X	X	X	X	X	X	X	X	X	X	X

K-Maps for functions J3, K3, J2, K2, J1, K1, J0 and K0 are

J3	00	01	11	10
00				
01			1	
11	X	X	X	X
10	X	X	X	X

J2	00	01	11	10
00			1	
01	X	X	X	X
11	X	X	X	X
10			X	X

J1	00	01	11	10
00		1	X	X
01		1	X	X
11	X	X	X	X
10			X	X

J0	00	01	11	10
00	1	X	X	1
01	1	X	X	1
11	X	X	X	X
10	1	X	X	X

K3	00	01	11	10
00	X	X	X	X
01	X	X	X	X
11	X	X	X	X
10		1	X	X

K2	00	01	11	10
00	X	X	X	X
01			1	
11	X	X	X	X
10	X	X	X	X

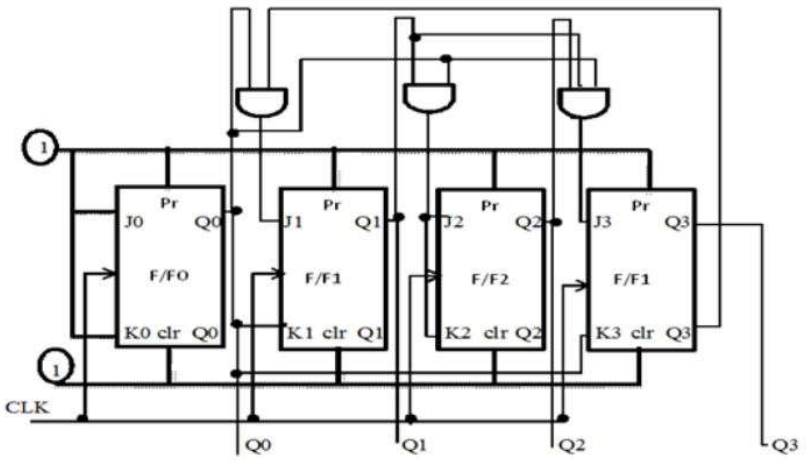
K1	00	01	11	10
00	X	X	1	
01	X	X	1	
11	X	X	X	X
10	X	X	X	X

K0	00	01	11	10
00	X	1	1	X
01	X	1	1	X
11	X	X	X	X
10	X	1	X	X

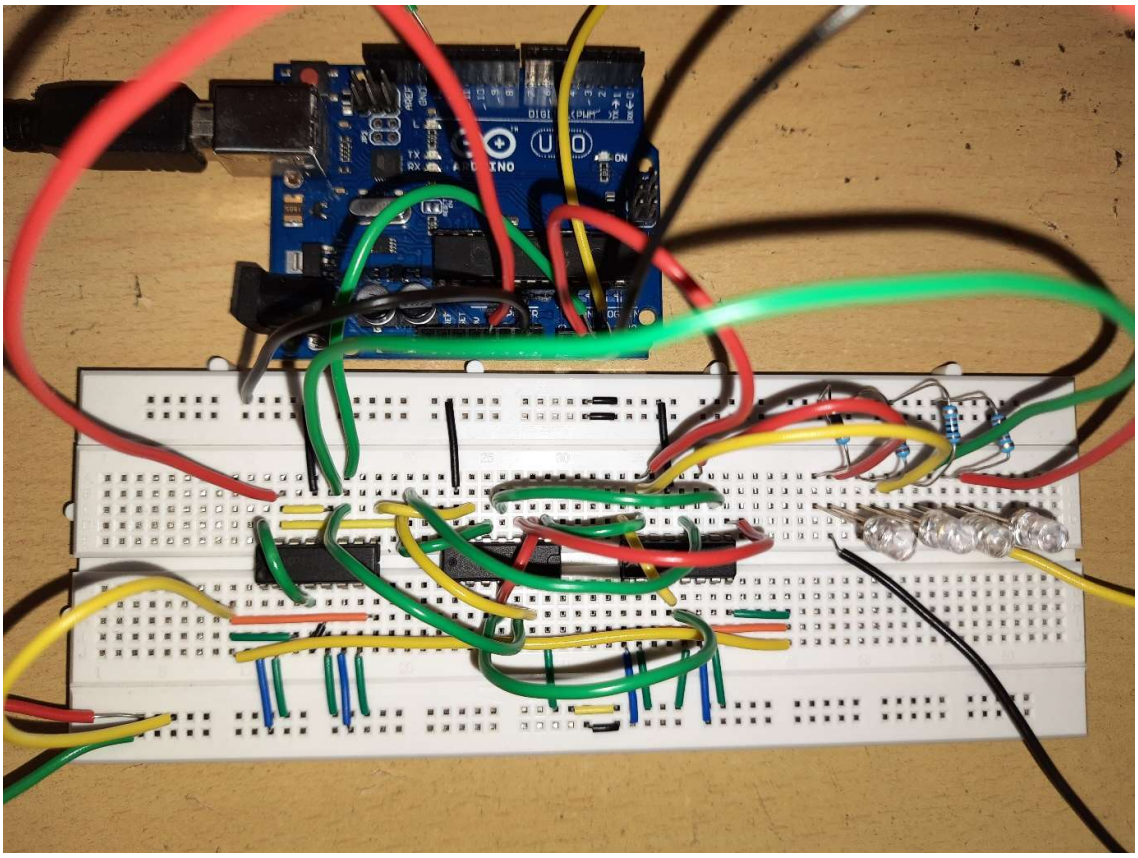
Hence, we get J's and K's as a function of Q3, Q2, Q1 and Q0 (present states).

$$J_3 = Q2 \cdot Q1 \cdot Q0 \qquad K_3 = Q0$$
$$J_2 = Q1 \cdot Q0 \qquad K_2 = Q1 \cdot Q0$$
$$J_1 = \overline{Q3} \cdot Q0 \qquad K_1 = Q0$$
$$J_0 = 1 \qquad K_0 = 1$$

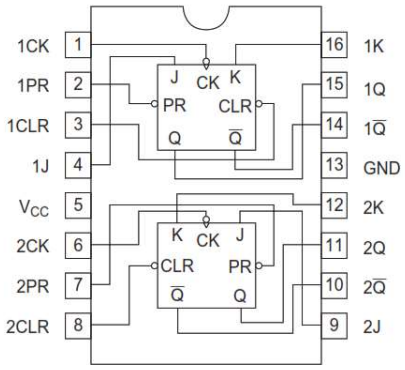
CIRCUIT DESIGN

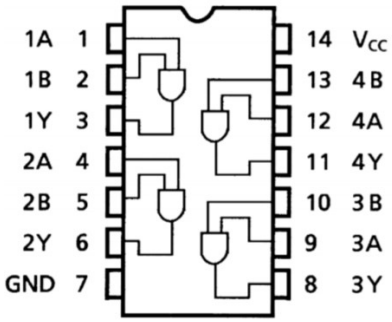


CIRCUIT

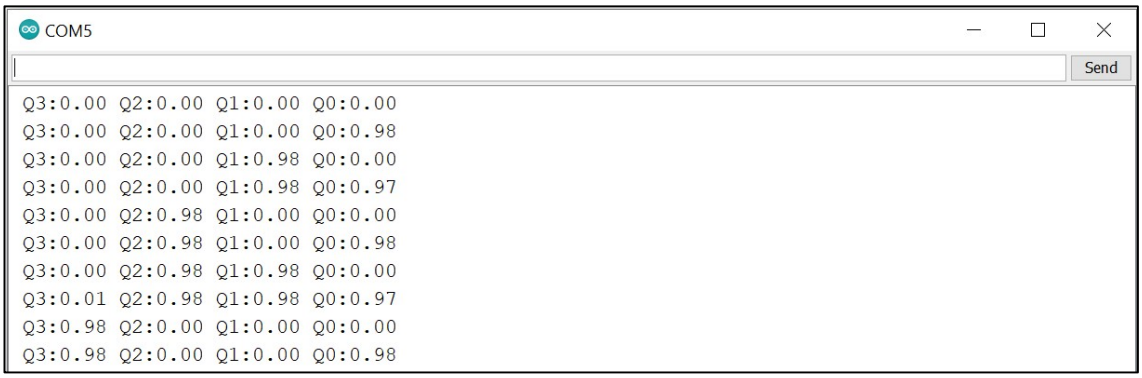


The JK Flip Flops used are HD74LS76AP (dual JK FF) and the and gates used for the combinational part of the circuit is SN74AS08N (quadruple 2 i/p AND gate). The pin diagram of JK FF and AND gate is





The clock of the circuit is generated using Digital write of Arduino. To illustrate the counting of the counter, we could use an LED display, but as it isn't available, we have used 4 LEDs to show the counting in binary format. It is done connecting the positive terminal of LED to the output of FF and connect the negative one to 1 kΩ resistor which is connected to ground. Hence, the LED glows when the FF output is high and doesn't glow when it is low.

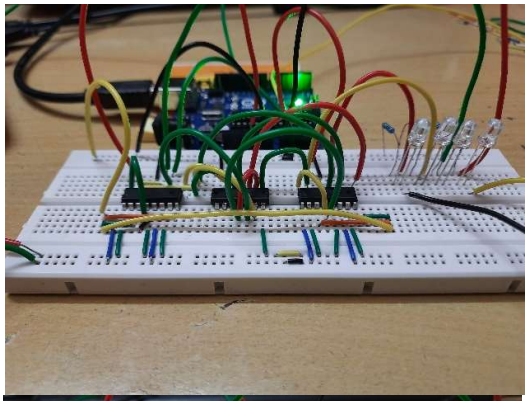


Output voltages of flipflop

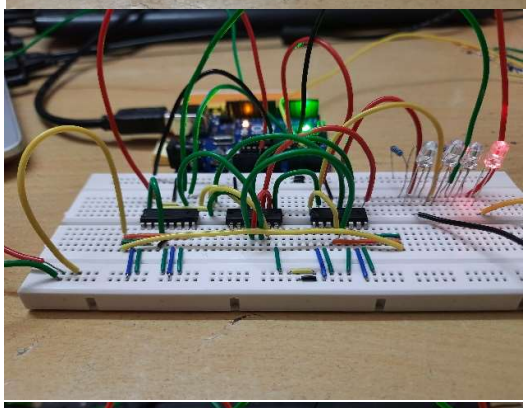
Code used

```
float Value0, Value1, Value2, Value3;
float V0, V1, V2, V3;

void setup()
{
 pinMode(13, OUTPUT);
 Serial.begin(9600);
}

void loop()
{
 digitalWrite(13, LOW);
 delay(2000);
 digitalWrite(13, HIGH);
 delay(2000);

 Value0 = analogRead(A3);
 V0 = (Value0) / 1023;
 Value1 = analogRead(A2);
 V1 = (Value1) / 1023;
 Value2 = analogRead(A1);
 V2 = (Value2) / 1023;
 Value3 = analogRead(A0);
 V3 = (Value3) / 1023;

 Serial.print(" Q3:");
 Serial.print(V3);
 Serial.print(" Q2:");
 Serial.print(V2);
 Serial.print(" Q1:");
 Serial.print(V1);
 Serial.print(" Q0:");
 Serial.print(V0);
 Serial.println("");
}
```

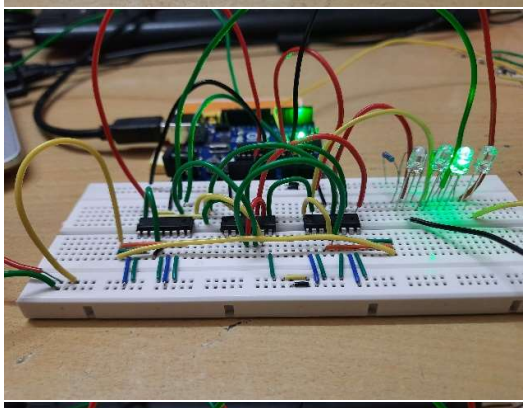
Given below are outputs



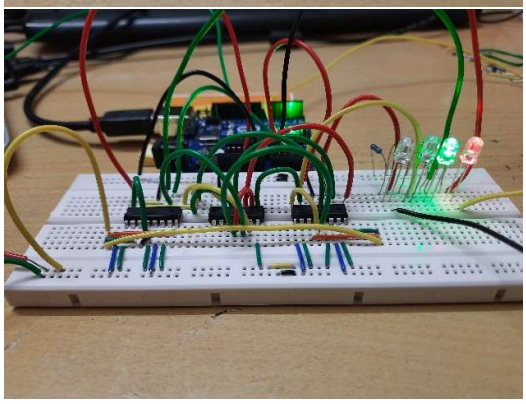
0000 (0)



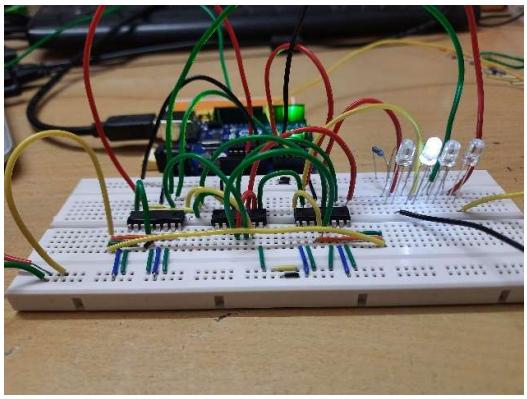
0001 (1)



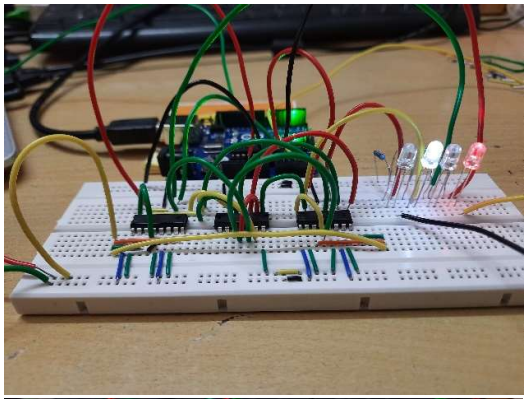
0010 (2)



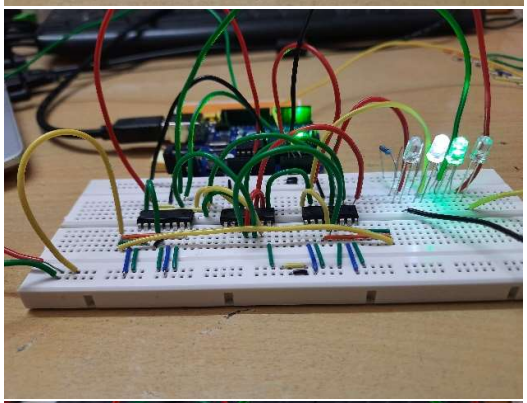
0011 (3)



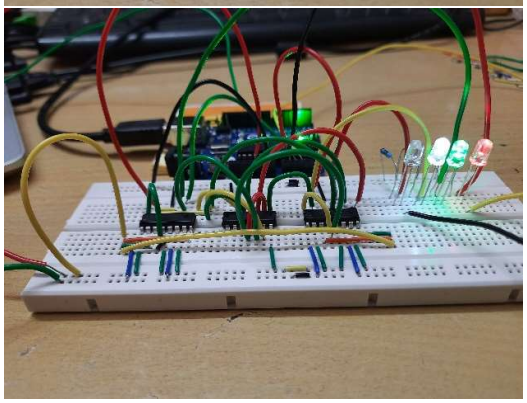
0100 (4)



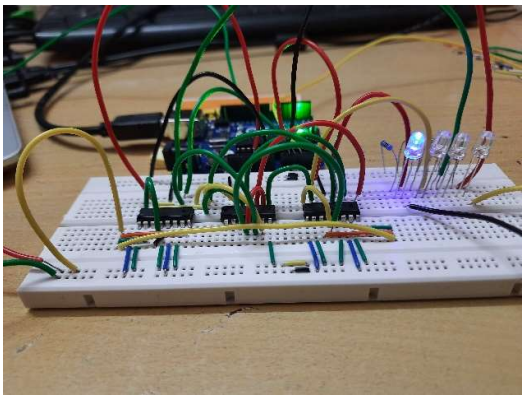
0101 (5)



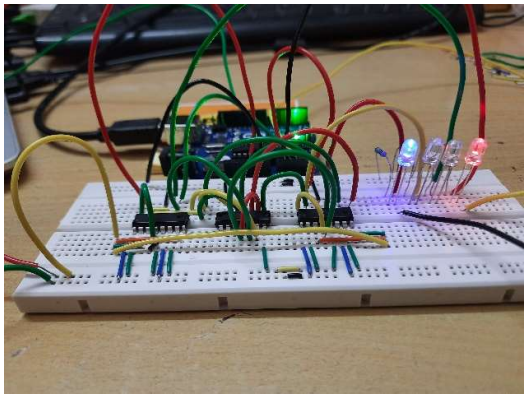
0110 (6)



0111 (7)



1000 (8)



1001 (9)